(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 309 257**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 88308827.0

(22) Date of filing: 23.09.88

(51) Int. Cl.[4]: B 29 C 45/17
B 29 C 45/34

(30) Priority: 25.09.87 GB 8722620

(43) Date of publication of application:
29.03.89 Bulletin 89/13

(84) Designated Contracting States:
AT BE CH DE ES FR GR IT LI LU NL SE

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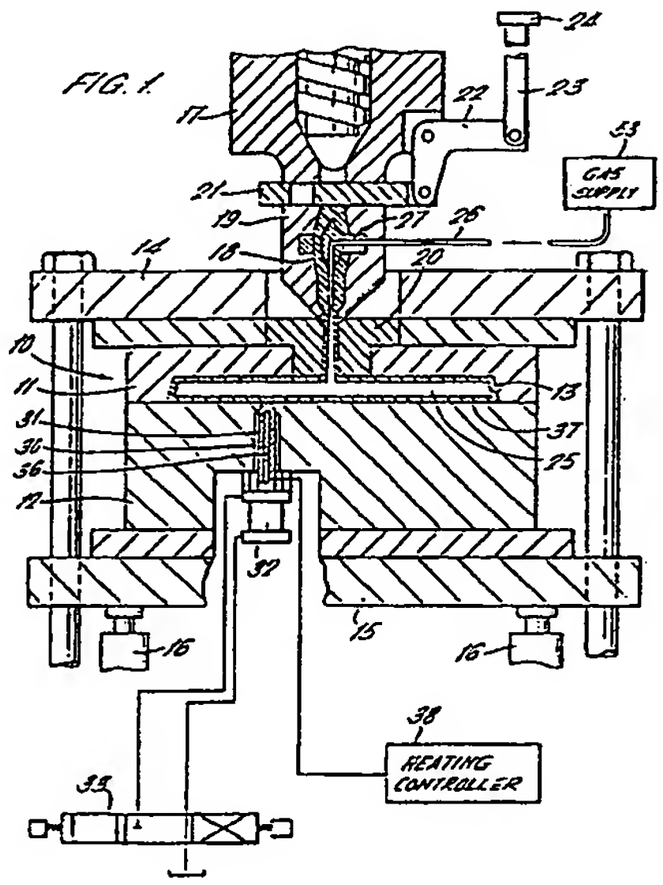
(54) Method and apparatus for injection moulding.

(57) An injection moulded plastics article is produced by introducing a stream of molten plastics material from an injection moulding machine cylinder into an article forming mould space (13). Pressurised gas is supplied into the interior of the molten plastics material to form a gas containing cavity (25) therein. The plastics material is then allowed to solidify and cool sufficiently so that the article can itself sustain the form dictated by the mould surface. The cavity is vented to reduce the pressure within the cavity to ambient pressure prior to opening of the mould. The step of venting the cavity is achieved by providing at at least one position which is separate from the plastics inlet and the gas inlet a vent passage (30) in the mould open at its inner end to a part of the interior of the mould at which the gas containing cavity (25) is formed, and a retractable closure (31) for opening and closing the vent passage at its inner end, maintaining the closure in its closed position during the forming of the article whereby the cavity wall is formed over the inner end of the vent passage and the closure therefor, and subsequently retracting the closure to allow the creation of a vent opening in the cavity wall in the area of the inner end of the vent passage through which vent opening gas from the cavity passes into the vent passage. Apparatus for carrying out the above process is also described.



EP 0 309 257 A2

Description

METHOD AND APPARATUS FOR INJECTION MOULDING

This invention relates to a method and apparatus for injection moulding.

More particularly the invention concerns the production of injection moulded plastics articles by introducing a stream of molten plastics material from an injection moulding machine cylinder into an article forming mould space, and supplying pressurised gas into the interior of the molten plastics material to form a cavity therein. When the plastics material has solidified and cooled sufficiently so that the article can itself sustain the form dictated by the mould surface, the gas containing cavity is vented to reduce the pressure within the cavity to ambient pressure. The mould is then opened to allow the moulded article to be removed therefrom.

It is known to introduce the gas through the injection nozzle which introduces the plastics material, and then to vent the cavity by a step known as "sprue break" in which the nozzle is withdrawn from the mould whereby a gap is created between the nozzle and the mould which allows the gas to pass from the cavity to atmosphere. However, some moulding machines are not equipped to permit sprue break. Also, it may be considered undesirable to vent the gas, e.g. nitrogen, into the environment of the moulding machine for health reasons. In each case, it would be preferable to vent the cavity at another position in the mould, if desired in a manner in which the gas may be readily channelled to a factory vent.

Forming openings during moulding operations is known per se. For example, it is known to generate a high excess pressure to cause a blow-mould to burst in the zone of an orifice to form a desired opening. Such a method would not be an acceptably controlled manner of venting.

It is also known to create a vent opening mechanically in the cavity wall of a moulded article by piercing or boring. However, the act of piercing would not itself ensure that the gas would be permitted to escape unless the piercing tool is first inserted and then withdrawn. If a hollow piercing tool is used, venting would be achieved, but it would be difficult to prevent the hollow tool from being blocked by plastics material during the step of introducing the plastics material into the mould space. The same would apply to the provision of a drill for boring a hole in the cavity wall. Thus both previously proposed methods are disadvantageous because they are slow, thereby adding to the moulding cycle time, and are impracticable.

It has further been suggested to seal the hole in the cavity wall through which the gas enters the cavity, by injecting a further quantity of plastics material, prior to the step of venting the cavity. Such a step may be disadvantageous because, with the hole blocked, it is no longer possible to alter the gas pressure within the cavity and thereby to maintain control of the gas pressure.

In a still further known arrangement, there is provided in association with the supply of pressurised gas a valve port for opening the cavity to atmosphere and a valve member for closing the port. During the supply of pressurised gas, the valve member is closed but the valve port is maintained open to the cavity. Thereby, after a moulding operation has been finished, the cavity can be vented by opening the valve member to connect the still open valve port to atmosphere.

In another known arrangement for injection moulding, a pin is positioned in the inner end of a vent passage for movement between an extended position in which the vent passage is closed and a retracted position in which the vent passage is open, and means are provided for moving the pin between its extended and retracted positions. However, in this arrangement, the inner end of the vent passage is not open to a part of the interior of the mould at which the gas containing cavity is to be formed. Also, as in other known arrangements, at the end of the moulding operation a vent opening exists in the cavity wall. The vent opening is not created by or on retraction of the pin.

According to the invention there is provided a method of producing an injection moulded plastics article comprising introducing a stream of molten plastics material from an injection moulding machine cylinder into an article forming mould space, supplying pressurised gas into the interior of the molten plastics material to form a gas containing cavity therein, allowing the plastics material to solidify and cool sufficiently so that the article can itself sustain the form dictated by the mould surface, and venting the cavity to reduce the pressure within the cavity to ambient pressure prior to opening of the mould, the step of venting the cavity being achieved by providing at at least one position which is separate from the plastics inlet a vent passage in the mould open at its inner end to a part of the interior of the mould at which the gas containing cavity is formed, and a retractable closure for opening and closing the vent passage at its inner end, characterised by providing the vent passage at a position which is also separate from the gas inlet, maintaining the closure in its closed position during the forming of the article whereby the cavity wall is formed over the inner end of the vent passage and the closure therefor, and subsequently retracting the closure to allow the creation of a vent opening in the cavity wall in the area of the inner end of the vent passage through which vent opening gas from the cavity passes into the vent passage.

In one embodiment on retraction of the closure the cavity wall is unsupported and the pressure of the gas within the cavity ruptures the cavity wall and thereby creates the vent opening.

Another embodiment comprises immersing a part of the closure in the cavity wall as it is formed to produce weak lines in the cavity wall whereby on retraction of the closure the weak lines assist the pressure of the gas to rupture the cavity wall and thereby create the vent opening.

A further embodiment comprises immersing a part of the closure in the cavity wall as it is formed to produce weak lines in the cavity wall whereby on retraction of the closure the weak lines assist the removal of a section of the cavity wall and thereby the creation of the vent opening. The part of the closure to be immersed may be undercut whereby retraction of the closure pulls said section from the cavity wall.

If desired heat may be applied at the inner end of the vent passage to assist the creation of the vent opening, for example, by applying heat to the closure.

The invention also provides apparatus for producing an injection moulded plastics article comprising means for introducing a stream of molten plastics material from an injection moulding machine cylinder into an article forming mould space, means for supplying pressurised gas into the interior of the molten plastics material to form a gas containing cavity therein, and at at least one position which is separate from the plastics inlet a vent passage in the mould open at its inner end to a part of the interior of the mould at which the gas containing cavity is to be formed, a retractable closure positioned in the inner end of the vent passage for movement between an extended position in which the vent passage is closed and a retracted position in which the vent passage is open, and means for moving the closure between its extended and retracted positions, characterised in that the position of the vent passage is also separate from the gas inlet.

In one embodiment, the inner end of the vent passage is open to the article forming mould space. In another embodiment the inner end of the vent passage is open to a part of the interior of the mould which is upstream of the article forming mould space.

Preferably the closure has a conical surface which engages a correspondingly shaped valve seat in the vent passage when the closure is in its extended position thereby closing the vent passage.

In one embodiment a part of the closure, in its extended position, becomes immersed in the cavity wall as it is formed, said part of the closure may also be shaped to assist the removal of a section from the cavity wall when the closure is retracted.

Preferably the closure is a pin extending lengthwise of the vent passage.

Means may be provided for applying heat at the inner end of the vent passage. For example, heating means may be provided internally of the closure.

The means for moving the closure is preferably a piston and cylinder.

In one embodiment the outer end of the vent passage is open to atmosphere. Alternatively, the vent passage may be connected to a factory vent or to means for collecting the gas.

By way of example, specific embodiments in accordance with the invention will be described with reference to the accompanying diagrammatic drawings in which:-

Figure 1 shows an injection moulding machine, in section;

Figure 2 is a detail sectional view of the retractable venting pin of the injection moulding machine of Figure 1;

Figures 3 to 5 show modified gas venting pins;

Figure 6 shows another injection moulding machine having two gas venting pins at different positions in the mould; and

Figures 7 to 9 show further embodiments of injection moulding machines in accordance with the invention and incorporating a gas venting pin at a variety of different positions in the mould.

This example is a development of a process for producing injection mouldings which is described generally in British Patent Specification No. 2139548. In that process there is provided a screw ram for introducing plastics material into a mould space, and a passageway through which pressurised gas is introduced under controlled conditions to create a gas containing cavity in the plastics material. Pressurisation in the gas is maintained whereby the pressurised gas in the plastics material causes the plastics material to flow throughout the mould space with the gas containing cavity within the plastics material, the cavity thereby extending with the plastics material. When the plastics material has extended over the whole of the mould space, the gas pressure within the cavity is still maintained to hold the plastics material positively against the mould surface as the plastics material solidifies and cools until the moulding can itself sustain the form dictated by the mould surface. Valve means are then opened for relieving the gas pressure within the gas containing cavity before the mould is opened.

In the known process, the position for introducing the pressurised gas may be at one or more selected positions either within the mould space or upstream of the article forming mould space. In each position, the gas is introduced through the respective passageway, and likewise emitted from the cavity through the same passageway during the subsequent venting stage of the moulding cycle.

In the present development of the above described process, the position for introduction of the pressurised gas may be similarly varied, although in a preferred arrangement, as in each embodiment described below, the pressurised gas is introduced through the injection nozzle for the plastics material. The difference of the present development compared with the known process is that separate means are provided for venting the gas containing cavity.

Referring to Figures 1 and 2 of the drawings, a mould 10 of an injection moulding machine has upper and lower parts 11, 12 defining an article forming mould space 13. The mould parts 11, 12 are mounted between a fixed upper platen 14 and a lower platen 15 movable by a hydraulic ram 16.

A screw ram 17 is provided for introducing molten thermoplastics material 18 through a nozzle assembly 19 and sprue insert 20 to the mould space 13. The nozzle assembly is provided with a shut-off slide valve 21 actuated by a bell-crank lever 22 and a link 23 connected to a hydraulic cylinder 24. The valve is shown in its closed position at the end of the

moulding cycle which includes the introduction of the plastics material. The closed valve 21 prevents any return movement of the plastics material to the barrel of the screw ram 17. The screw ram may then be refilled with plastics material in preparation for the next moulding cycle.

In this embodiment, the passageway through which pressurised gas is introduced to create a gas containing cavity 25 in the plastics material 18 is the bore of a pipe 26 connected to a supply 53. The supply pipe 26 enters the hub of a spider insert 27 in the nozzle assembly 19 and is then directed axially in the direction of flow of the plastics material to the desired position at which the gas is to be injected into the plastics material. The gas supply means 53 which supply pressurised gas to the pipe 26 are described in Specification No. 2139548. If desired, the pressurised gas may be introduced at a position other than through the nozzle assembly, for example directly into the article forming mould space 13 or at an intermediate position within the sprue or, as provided in some of the other embodiments described below, the runner system interconnecting the sprue to at least one article forming mould space.

In the lower mould part 12, at a position separate from the plastics material inlet and the pressurised gas inlet, there is provided a vent passage 30 which at its upstream or inner end, i.e. at the end adjacent the article forming mould space 13, is open to the mould space 13 and at its downstream or outer end, in this embodiment, is open to atmosphere. Alternatively, the outer end may be sealed and a branch passageway provided through the lower mould part 12 extending from the vent passage to an outlet which may be connected to a factory vent or a gas collecting chamber. The factory vent would avoid the discharge of gas into the work area of the moulding machine. In the case of a gas collecting chamber being employed, the gas collected could be recirculated for use in a succeeding moulding cycle.

Positioned in the inner end of the vent passage 30 is a retractable closure which, in this embodiment, is a pin 31 of smaller diameter than the bore of the vent passage 30, the pin extending lengthwise of the vent passage and being carried by the piston of an hydraulic, pneumatic or mechanical ram 32 for moving the pin between extended and retracted positions. In this embodiment, the ram is operated hydraulically by a solenoid operated control valve 33. In the extended position of the pin 31 (Figure 1), a conical surface 34 of the pin engages a correspondingly shaped valve seat 35 thereby closing the vent passage 30 at its inner end which is also substantially blocked by the leading end of the pin. In this embodiment the leading end of the pin 31 is flush with the adjacent surface of the article forming mould space and is close fitting thereby preventing plastics material from entering the vent passage 30. Also, within a bore in the pin 31, is a cartridge heater 36 for maintaining the pin at a desired temperature, especially at its leading end. Control of the heater is by means of a heating controller 38.

Generally, the process of injection moulding is the same as described in detail in British Patent Specification No. 2139548. It is thus sufficient to explain that at the start of the moulding cycle, the pin 31 is maintained by the ram 32 in its extended position so that the vent passage 30 is closed. The screw ram 17 contains plastics material and the slide valve 21 is open. The machine is also set for delivering pressurised gas through the pipe 26. Operation of the screw ram 17 introduces the plastics material 18 into the article forming mould space 13 through the nozzle assembly 19 and the sprue 20. Simultaneously a gas timer is started so that when the outlet end of the pipe 26 is immersed in plastics material, pressurised gas is introduced through the pipe into the plastics material. Pressurisation in the gas is maintained whereby the gas in the plastics material causes the plastics material to flow throughout the mould space with the gas containing cavity within the plastics material, the cavity thereby extending with the plastics material until the plastics material has extended over the whole of the mould space. When the desired amount of plastics material has been introduced into the mould, the slide valve 21 is closed and the screw ram refilled with plastics material. Meanwhile, the supply of pressurised gas is terminated, but pressurisation in the gas within the cavity is maintained to hold the plastics material in the mould space positively against the mould surface as the plastics material solidifies and cools until the moulding can itself sustain the form dictated by the mould surface.

It will be appreciated that during the moulding operation a wall or layer of the plastics material is formed over the inner end of the vent passage and the leading end of the pin 31 in the vent passage (Figure 1). However, in this embodiment, by means of the heater 36, under the control of the heating controller 38, this section of the cavity wall in the area of the inner end of the vent passage 30 is maintained soft relative to the remainder of the cavity wall. Then, on completion of the moulding operation described above, the valve 33 is operated to cause the ram 32 to retract the pin 31. This movement of the pin 31 opens the valve 34, 35 and removes the support given by the pin for the soft section of the cavity wall. As a result, the gas pressure in the cavity 25 stretches the soft section of the cavity wall downwardly until it bursts or ruptures (Figure 2) thereby creating a vent opening in the cavity wall in the area of the inner end of the vent passage 30 which allows the gas to pass from the cavity 25 through the vent passage to atmosphere. Alternatively, the gas may be fed from the vent passage 30, e.g. through a branch passage (not shown) in the lower mould part 12, to a factory vent or to a gas collecting chamber. After venting, the pressure within the cavity is equal to ambient pressure and the mould 10 is opened for removal of the moulded article.

It will be appreciated that in the above described embodiment, opening of the cavity 25 for venting is achieved by allowing the gas pressure to burst or rupture the cavity wall to create a vent opening therein in the area of the inner end of the vent passage.

In alternative embodiments, shaping of the leading

end of the pin can be employed to mechanically effect or assist in the creation of a vent opening in the cavity wall. For example, in Figure 3, there is shown a construction of pin 31 in which the leading end or head of the pin projects into the interior of the mould and has a central recess 40 forming an upwardly facing wall or points 41 which become immersed in the cavity wall during the moulding operation. The wall or points serve to produce weak lines 52 in the cavity wall whereby on retraction of the pin the gas pressure causes the section 42 of the cavity wall to rupture along the weak lines thereby creating a vent opening in the cavity wall in the area of the inner end of the vent passage for the gas to pass therethrough. This construction of pin is capable of operating with or without the application of additional heat to the pin head. In either case, the cavity wall will rupture on retraction of the pin 31 by the ram 32.

Figures 4 and 5 illustrate two examples of embodiment in which the leading end or head of the pin creates a mechanical lock with the plastics material which on retraction of the pin removes a section of the cavity wall downwardly with the pin thereby creating a vent opening in the cavity wall in the area of the inner end of the vent passage. In Figure 4 the pin 31 has a head 43 which is undercut beneath the internal surface of the lower mould part 12. During the moulding operation, a localised depression 44 (as shown) is formed above the deep portion of the plastics material which is locked to the pin thereby creating weak lines 52 along which the cavity wall will rupture. Similar weak lines 52 are also created in the construction of Figure 5 in which the head 45 of the pin 31 protrudes upwardly into the interior of the mould and is undercut above the surface of the lower mould part 12. Again, each of these embodiments of pin may be employed with or without the use of a heater 36.

Full removal of a section of the cavity wall is not necessary, providing that the cavity wall is ruptured on retraction of the pin, whether by the pin itself or with the assistance of the gas pressure in the cavity, to create a vent opening. However, in the case of each embodiment in which retraction of the pin does effect the removal of a section of the cavity wall, it may be desirable to extract that portion of plastics material from the leading end of the pin between moulding cycles. Alternatively, it may be allowed to remain, in which case during the succeeding moulding cycle it will be resoftened and form part of the cavity wall of the next article.

The embodiments of Figures 6 to 9 are similar to the injection moulding machine of Figures 1 to 3 and the moulding process for each of these embodiments remains unchanged. The only differences are the formation of the mould space and the location of the or each gas vent pin.

More particularly, in Figure 6, the mould space 13 has two article forming portions 46, 47 interconnected by a common central portion 48. The downstream end of the sprue 20 opens into the central portion 48 which forms a runner feeding plastics material and the gas containing cavity therein to the two article forming portions 46, 47. Separate gas vent pins 31 are provided for venting the part of the gas containing cavity in each article forming portion. In this embodiment, the vent passage 30 associated with the right-hand article forming portion 47 is open to the article forming mould space 13, whilst the vent passage 30 associated with the left-hand article forming portion 46 is open to the common central portion 48. As shown, the gas containing cavity 25 formed during the moulding process is united throughout both article forming portions 46, 47, the common central portion 48 and the sprue 20. Thereafter, operation of the rams 32 to retract the pins 31 creates two vent openings in the cavity wall which allow the gas to pass from the cavity 25 through the respective vent passage 30 to atmosphere.

In Figure 7, the mould space 13 again has two article forming portions 46, 47 but there is only one vent passage 30 and associated vent pin 31 disposed centrally of the common interconnecting portion 48, and directly beneath the sprue 20. Retraction of the pin 31 allows gas to be vented from the cavity 25 extending throughout each article forming portion 46, 47, the common interconnecting portion 48 and the sprue 20.

Figure 8 illustrates an embodiment in which the downstream end of the sprue 20 is associated with an extension part 49 of the article forming portion 50 of the mould space 13. The vent passage and associated vent pin are also arranged at 90° to the sprue 20 to indicate that their position in the mould may be varied. If desired, the vent passage may be provided in the sprue insert 20 of the mould 10.

In the embodiment of Figure 9, the downstream end of the sprue 20 and the vent passage 30 open directly into the article forming portion 51 of the mould space 13, one above the other.

The invention is not restricted to the details of the specific embodiments described above. For example, heating means for the pin or other closure in the vent passage may be provided in the surrounding wall of the vent passage rather than in the closure itself. Also, at least the part of the closure adjacent the cavity wall, e.g. the head of the pin in the above described embodiments, may be constructed of a material, for example beryllium copper alloy, which is efficient at retaining the heat transmitted thereto from heating means, as above, or from the plastics material or the mould itself, thereby further assisting the rupture of the cavity wall.

Claims

1. A method of producing an injection moulded plastics article comprising introducing a stream of molten plastics material from an injection moulding machine cylinder into an article forming mould space (13), supplying pressurised gas into the interior of the molten plastics material to form a gas containing cavity (25) therein, allowing the plastics material to

solidify and cool sufficiently so that the article can itself sustain the form dictated by the mould surface, and venting the cavity to reduce the pressure within the cavity to ambient pressure prior to opening of the mould, the step of venting the cavity being achieved by providing at least one position which is separate from the plastics inlet a vent passage (30) in the mould open at its inner end to a part of the interior of the mould at which the gas containing cavity (25) is formed, and a retractable closure (31) for opening and closing the vent passage at its inner end, characterised by providing the vent passage (30) at a position which is also separate from the gas inlet (26), maintaining the closure (31) in its closed position during the forming of the article whereby the cavity wall is formed over the inner end of the vent passage and the closure therefor, and subsequently retracting the closure to allow the creation of a vent opening in the cavity wall in the area of the inner end of the vent passage through which vent opening gas from the cavity (25) passes into the vent passage.

2. A method as claimed in Claim 1, characterised in that on retraction of the closure (31) the cavity wall is unsupported and the pressure of the gas within the cavity (25) ruptures the cavity wall and thereby creates the vent opening.

3. A method as claimed in Claim 1 or Claim 2, characterised by immersing a part of the closure (31) in the cavity wall as it is formed to produce weak lines in the cavity wall whereby on retraction of the closure the weak lines assist the pressure of the gas to rupture the cavity wall and thereby create the vent opening.

4. A method as claimed in Claim 1, characterised by immersing a part of the closure (31) in the cavity wall as it is formed to produce weak lines in the cavity wall whereby on retraction of the closure the weak lines assist the removal of a section of the cavity wall and thereby the creation of the vent opening.

5. A method as claimed in Claim 4, characterised in that the part of the closure (31) to be immersed is undercut whereby retraction of the closure pulls said section from the cavity wall.

6. A method as claimed in any one of the preceding claims, characterised by the step of applying heat at the inner end of the vent passage (30) to assist the creation of the vent opening.

7. A method as claimed in Claim 6, characterised in that the heat is applied by heating the closure (31).

8. Apparatus for producing an injection moulded plastics article comprising means (17) for introducing a stream of molten plastics material from an injection moulding machine cylinder into an article forming mould space (13), means for supplying pressurised gas into the interior of the molten plastics material to form a gas containing cavity (25) therein, and at at least one position which is separate from the plastics inlet (19) a vent passage (30) in the mould (10) open at its inner end to a part of the interior of the mould at which the gas containing cavity is to be formed, a retractable closure (31) positioned in the inner end of the vent passage for movement between an extended position in which the vent passage is closed and a retracted position in which the vent passage is open, and means (32) for moving the closure between its extended and retracted positions, characterised in that the position of the vent passage is also separate from the gas inlet (26).

9. Apparatus as claimed in Claim 8, characterised in that the inner end of the vent passage (30) is open to the article forming mould space (13).

10. Apparatus as claimed in Claim 8, characterised in that the inner end of the vent passage (30) is open to a part of the interior of the mould (10) which is upstream of the article forming mould space (13).

11. Apparatus as claimed in any one of Claims 8 to 10, characterised in that the closure (31) has a conical surface (34) which engages a correspondingly shaped valve seat (35) in the vent passage (30) when the closure is in its extended position thereby closing the vent passage.

12. Apparatus as claimed in any one of Claims 8 to 11, characterised in that a part of the closure (31), in its extended position, becomes immersed in the cavity wall as it is formed.

13. Apparatus as claimed in Claim 12, characterised in that said part of the closure (31), in its extended position, protrudes into the interior of the mould.

14. Apparatus as claimed in Claim 12 or Claim 13, characterised in that said part of the closure (31) is shaped to assist the removal of a section from the cavity wall when the closure (31) is retracted.

15. Apparatus as claimed in any one of Claims 12 to 14, characterised in that the closure (31) is undercut to provide a head which becomes immersed in the cavity wall as it is formed.

16. Apparatus as claimed in any one of Claims 8 to 15, characterised in that the closure is a pin (31) extending lengthwise of the vent passage.

17. Apparatus as claimed in any one of Claims 8 to 25 16, characterised in that means (36) are provided for applying heat at the inner end of the vent passage (30).

18. Apparatus as claimed in Claim 17, characterised in that the heating means (36) are provided internally of the closure (30).

19. Apparatus as claimed in any one of Claims 8 to 18, characterised in that the means (32) for moving the closure (31) is a piston and cylinder.

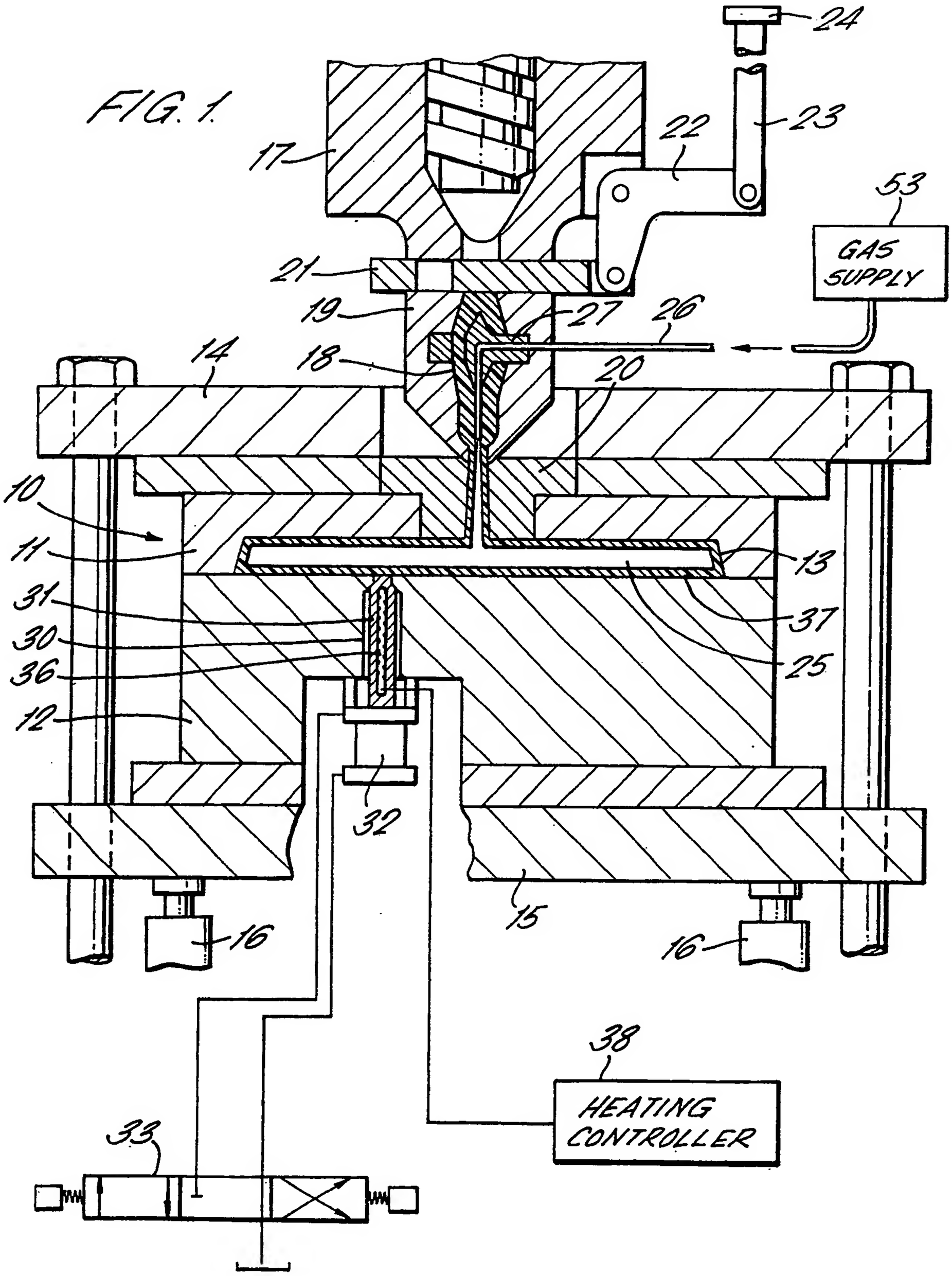
20. Apparatus as claimed in any one of Claims 8 to 19, characterised in that the outer end of the vent passage (30) is open to atmosphere.

21. Apparatus as claimed in any one of

Claims 8 to 19, characterised in that the vent passage (30) is connected to a factory vent.

22. Apparatus as claimed in any one of Claims 8 to 9, characterised in that the vent passage (30) is connected to means for collecting the gas.

FIG. 1.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HEATING CONTROLLER
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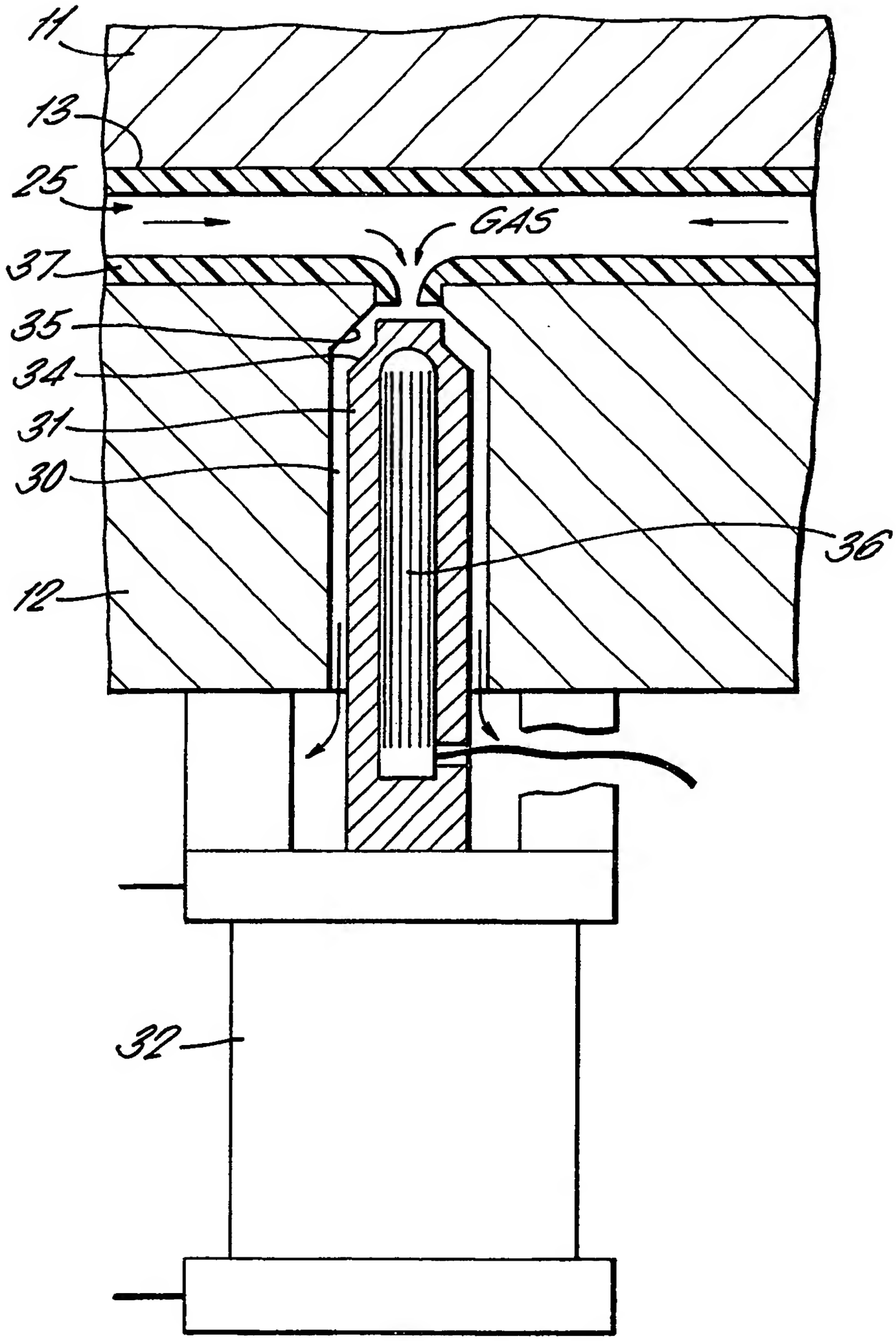
FIG. 2.



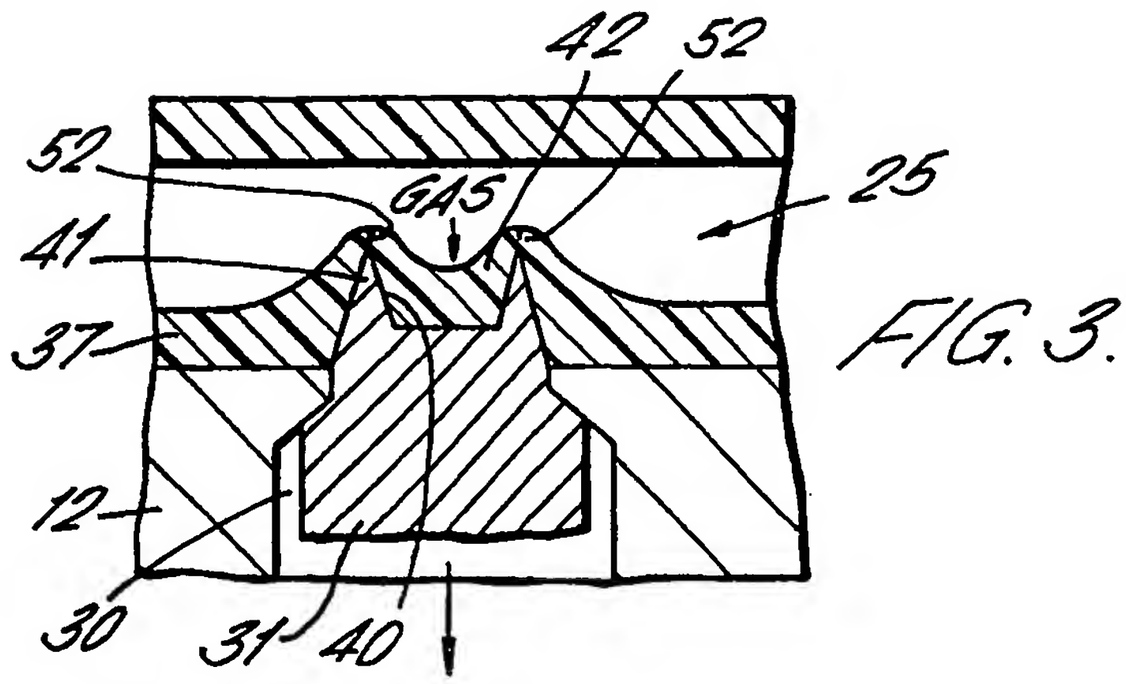


FIG. 3.

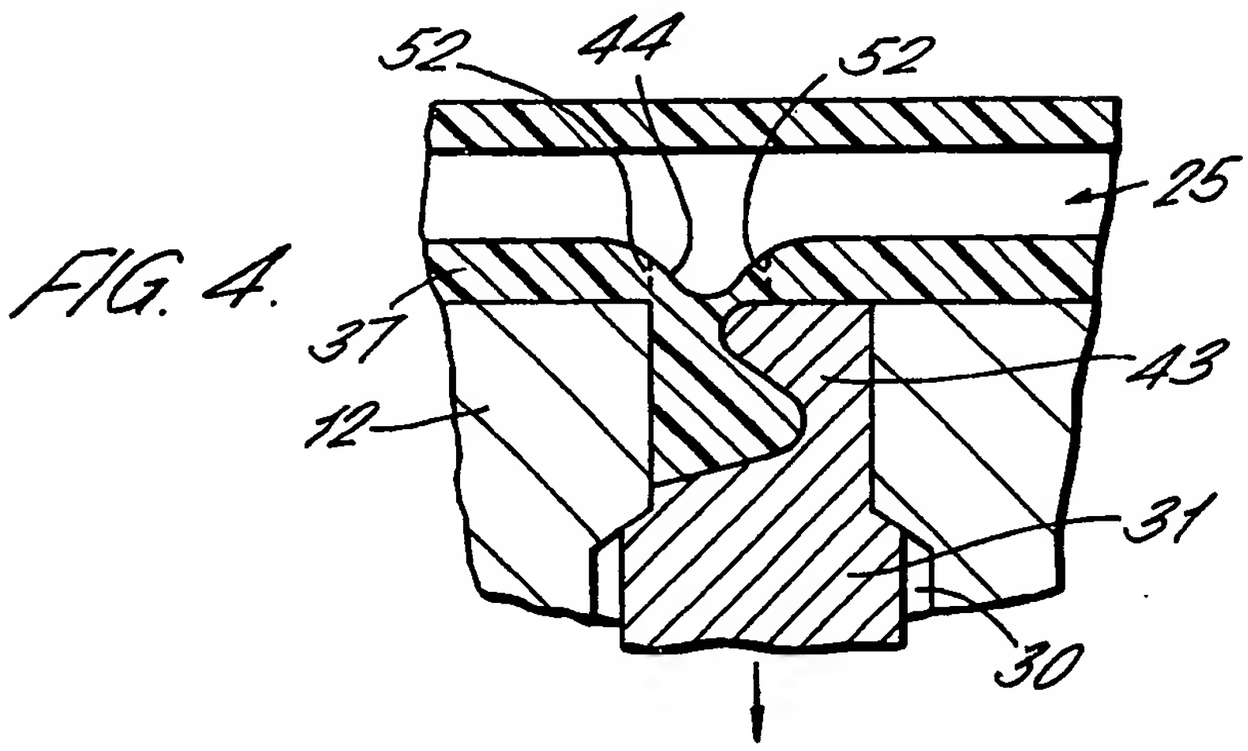


FIG. 4.

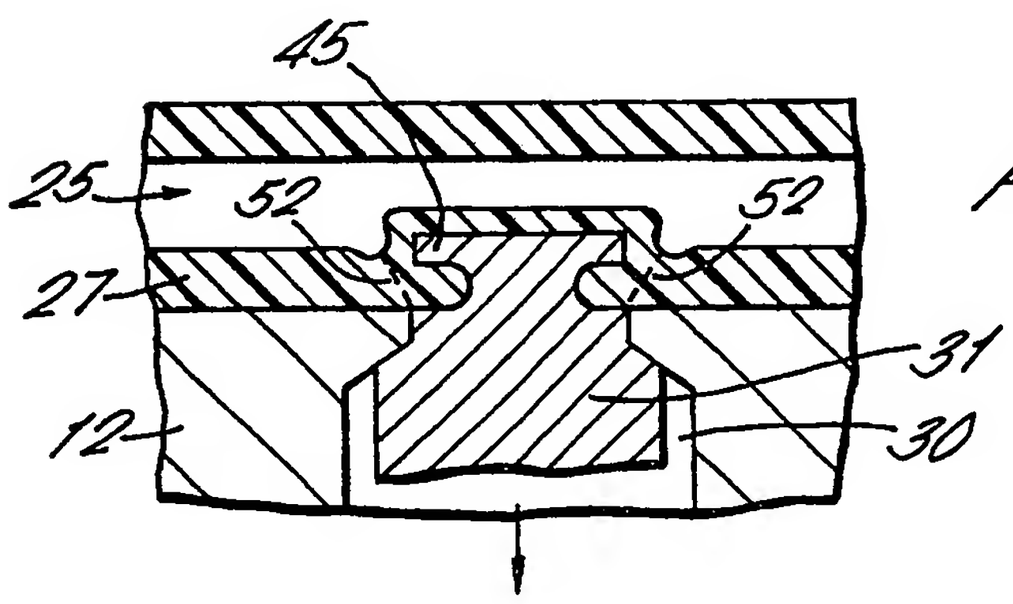


FIG. 5.

FIG. 6.

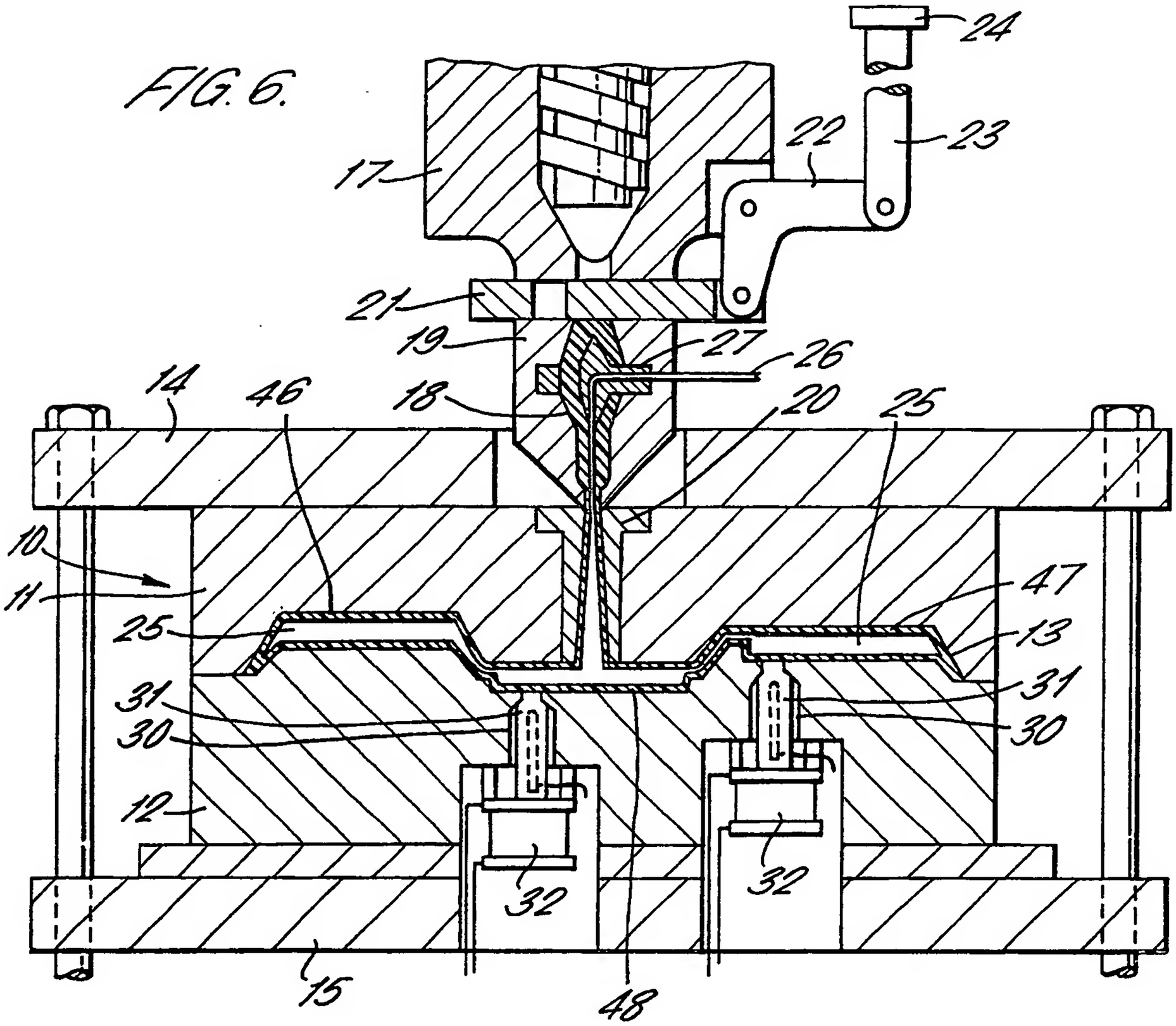

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FIG. 8.

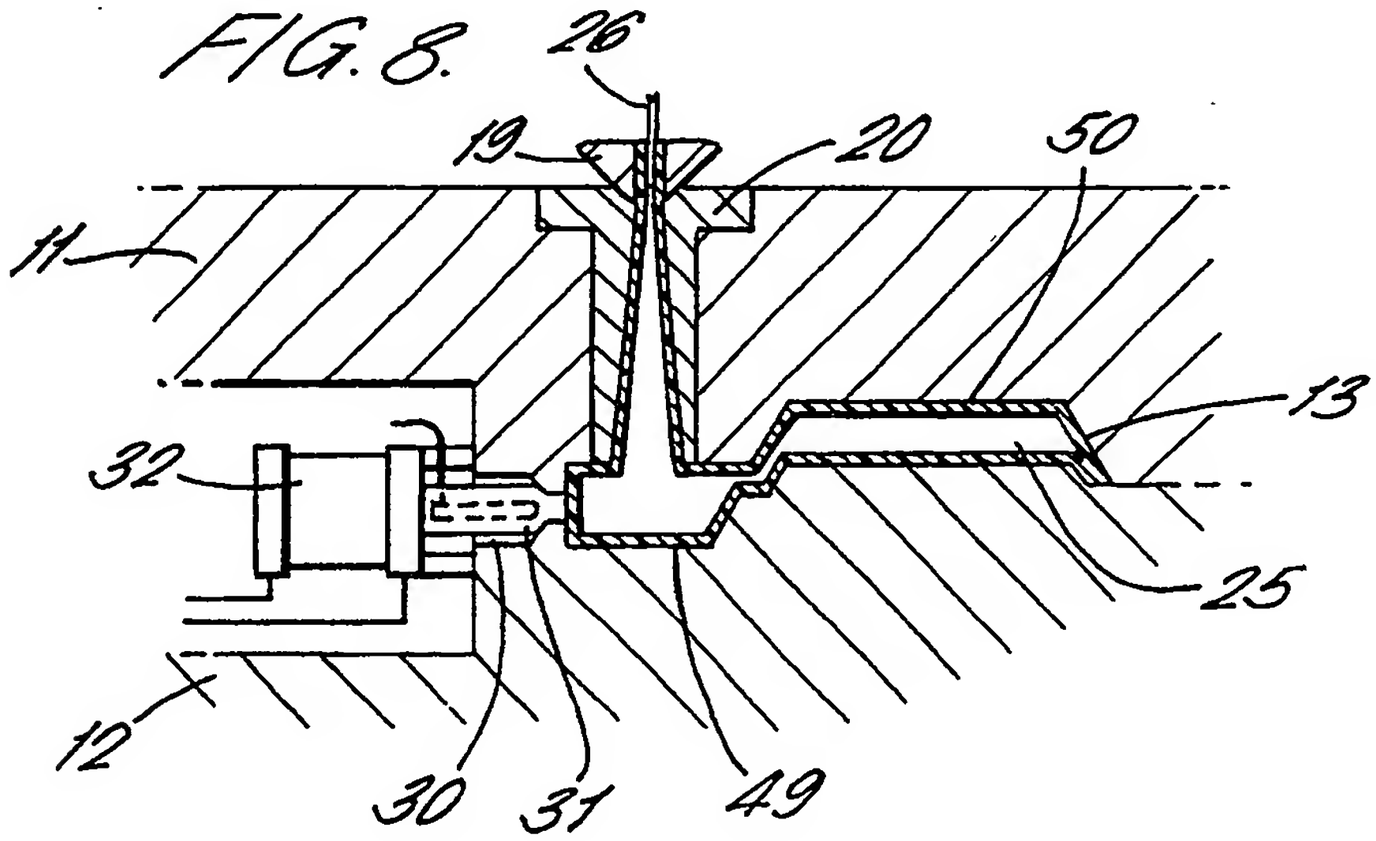
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FIG. 7.

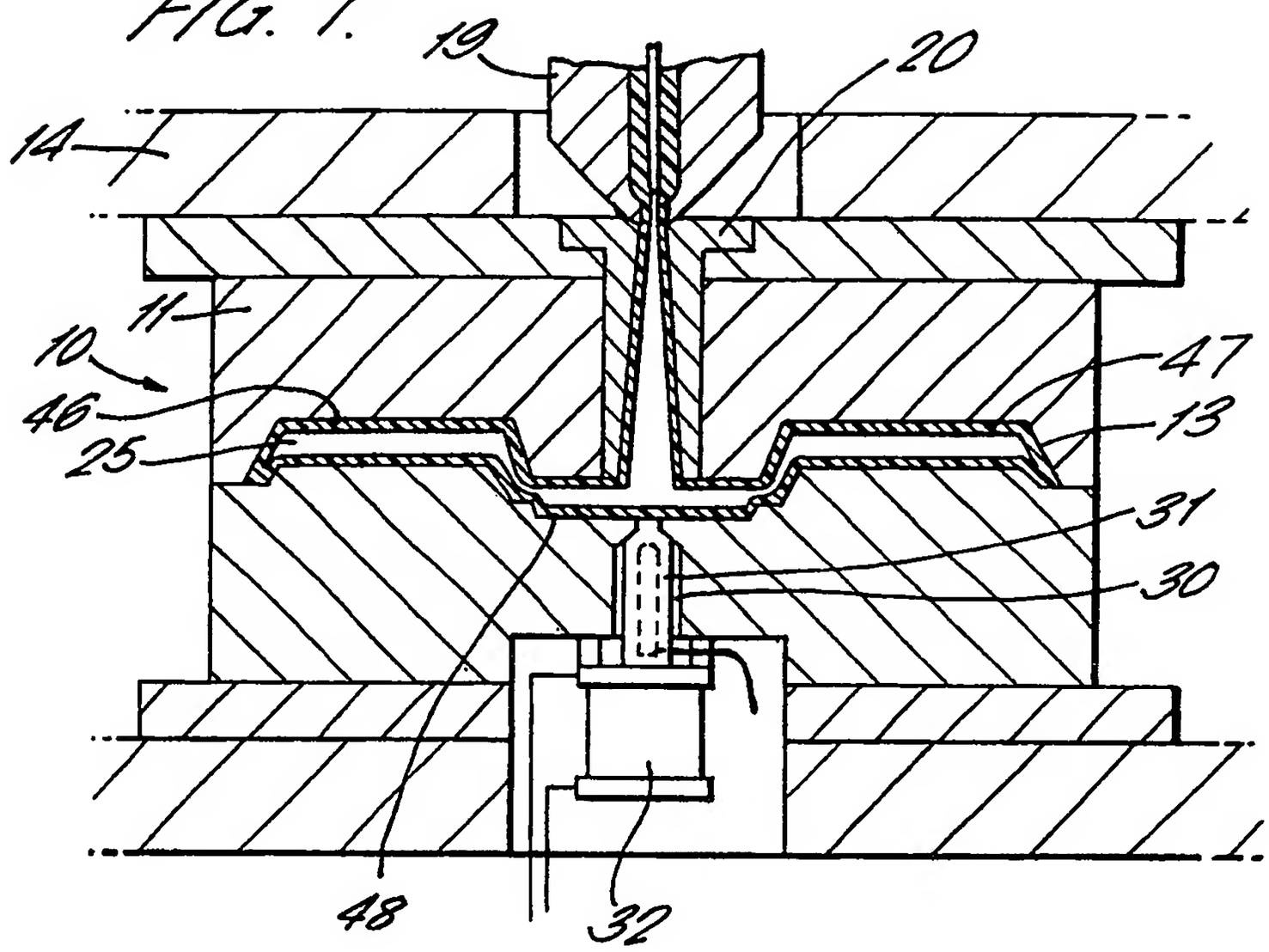

FIG. 9.